

DOCUMENT RESUME

ED 399 525

CS 012 608

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TITLE The Role of Epistemological Beliefs and Motivational Goals in Ethnically Diverse High School Students' Learning from Science Text.
PUB DATE Nov 95
NOTE 30p.; Paper presented at the Annual Meeting of the National Reading Conference (New Orleans, LA, November 29-December 2, 1995).
PUB TYPE Reports - Research/Technical (143) -- Speeches/Conference Papers (150)
EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Change Strategies; High Schools; *High School Students; Inner City; Misconceptions; Prior Learning; Reading Research; *Science Instruction; *Scientific Concepts; *Text Structure; Urban Education
IDENTIFIERS *Diversity (Student); New York City Board of Education; *Refutation Text

ABSTRACT

A study examined the relationship between two variable sets: (1) epistemological beliefs (Quick Learning, Simple-Certain Knowledge, and Innate Ability) and performance goals; and (2) conceptual understanding and application reasoning in conceptual change learning. In addition, effects of different kinds of prior knowledge on conceptual change learning were investigated. Subjects were 95 eleventh- and twelfth-grade students enrolled in science classes at an inner-city public high school in New York City. Results from repeated measures ANOVA (Analysis of Variance) indicated that refutational text was effective in facilitating conceptual change learning. Results from canonical correlation analyses demonstrated that beliefs about innate ability contributed the most to conceptual change learning, whereas beliefs about quick learning contributed the least. Findings suggest that beliefs about innate ability are an important factor in conceptual change learning among inner-city high school students. (Contains 38 references and 5 tables of data.) (Author/RS)

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Running Head: EPISTEMOLOGICAL BELIEFS

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The Role of Epistemological Beliefs and
Motivational Goals in Ethnically Diverse High School
Students' Learning from Science Text

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Paper presented at the annual meeting of the National Reading Conference, New Orleans,
LA, November, 1995.

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Abstract

This study examined the relationship between two variable sets: (a) epistemological beliefs (Quick Learning, Simple-Certain Knowledge, and Innate Ability) and performance goals, and (b) conceptual understanding and application reasoning in conceptual change learning. In addition, effects of different kinds of prior knowledge on conceptual change learning were investigated. The study involved 95 11th- and 12th-grade students enrolled in science classes at an innercity public high school in New York City. Results from repeated measures ANOVA indicate that refutational text is effective in facilitating conceptual change learning. The results from canonical correlation analyses demonstrate that beliefs about innate ability contribute the most to conceptual change learning, whereas beliefs about quick learning contribute the least. The results of this study suggest that beliefs about innate ability are an important factor in conceptual change learning among innercity high school students.

The Role of Epistemological Beliefs and
Motivational Goals in Ethnically Diverse High School
Students' Learning from Science Text

The social-cognitive model of motivation proposed by Dweck and Leggett (1988) has important implications in conceptual change learning. High school students who endorse performance goals and hold naive epistemological beliefs about learning and knowledge are less likely to overcome their alternative conceptions about a science concept than those who support learning goals and have more matured beliefs (Qian & Alvermann, 1995). In a difficult learning situation such as conceptual change learning, students' persistence, sophistication of their learning strategies, and expectancy of future success are strongly associated with their motivational goals and beliefs about intelligence. Students who pursue performance goals are concerned with gaining favorable judgments about their competence. In contrast, students who pursue learning goals are concerned with increasing their competence.

According to Dweck and Leggett (1988), students' pursuit of different goals is due to different belief systems about intelligence. Students who perceive intelligence as a fixed trait are classified as fixed entity theorists. These students tend to avoid challenging or frustrating learning situations, give up easily, and expect future failure to be beyond their power or ability. In contrast, students who perceive intelligence as a quality that can be improved through learning are classified as incremental theorists. They are more likely to persist in pursuing for learning goals, sophisticate their strategies in a difficult learning situation, attribute difficulties to controllable factors, and expect future success.

The Dweck and Leggett (1988) model has shed light on conceptual change learning by taking students' motivational goals and beliefs about intelligence into account. According to this theory, students who endorse performance goals and have

naïve beliefs about intelligence may give up easily in conceptual change learning because of challenges they face and difficulties they experience in learning the science concept from expository text. Specifically, students with alternative conceptions about a science concept have to face challenges from classroom instruction that directly confront their alternative conceptions, as well as their own rigid and oversimplified knowledge about the concept.

Rumelhart and Norman's (1988) notions of accretion, tuning, and restructuring also offer insight into conceptual change learning by taking students' different kinds of prior knowledge into account. Students who need to tune or restructure their prior knowledge are more likely to experience difficulties in conceptual change learning than are those who need only to accrete their existing knowledge. Accretion refers to adding new information to the existing valid, but incomplete, knowledge structure. Tuning is a substantially more significant kind of learning that involves moderate changes or modifications in the existing knowledge structure. In restructuring, students go through the most significant or difficult learning process that involves the replacement of existing knowledge with entirely new knowledge. Students who possess different kinds of prior knowledge may respond to refutational text in different ways. For example, students who simply need to accrete may find that learning is relatively easy because their extant knowledge is consistent with the text information. In contrast, students who need to tune or restructure their prior knowledge may experience discrepancies between their misconceived knowledge and text information.

In studying conceptual change learning, very few researchers have examined the effects of different kinds of prior knowledge on students' learning of counterintuitive science concepts (Griffiths, Thomey, Cooke, & Normore, 1988; Qian & Alvermann, 1995). In the Qian and Alvermann study, the investigation of different

kinds of prior knowledge in conceptual change learning was exploratory because of the nature of the post hoc questions they posed. The present study, which examines the contribution of students' epistemological beliefs and motivational goals to conceptual change learning, takes different kinds of prior knowledge into account. In the following, research on motivational goals, epistemological beliefs, types of text will be discussed.

In studying motivational goals, previous research has demonstrated that students who endorse learning goals tend to use high level cognitive strategies like elaboration and organization, resort to metacognitive and self-regulatory strategies (e. g., planning, comprehension, and monitoring), seek challenging learning tasks, and have positive affect (Ames & Archer, 1988; Dweck, 1986; Elliott & Dweck, 1988; Nolen, 1988; Pintrich & De Groot, 1990; Pintrich & Garcia, 1991). Nolen attempted to examine the role of goal orientations in high school students' learning from science texts. The results on the free and cued recalls, however, were not meaningful because of the floor effects (Nolen, 1988). The relation between students' goal orientations and conceptual change in learning from science texts remains unclear despite a sizable body of research literature on motivational goals. The present study was based on the theory proposed by Dweck and Leggett (1988) to explain differences found in affective responses and cognitive functioning between performance goal-oriented and learning goal-oriented students. Performance goal-oriented students are likely to be debilitated by failure, whereas learning goal-oriented students are likely to escalate effort in the face of difficulties.

Dweck and Leggett (1988) also hypothesized that students have different implicit theories about intelligence. Their theoretical model contends that students' implicit theories about intelligence affect their behaviors, affective responses, and cognitive functioning. According to the Dweck and Leggett model, students who

believe that intelligence is a fixed entity are more likely to have negative affects (e.g., anxiety or a sense of shame) and maladaptive cognitive functioning than those who believe it is malleable.

A number of studies have documented that epistemological beliefs predict students' academic learning and affective response. Researchers (Diener & Dweck, 1978, 1980; Ryan, 1984; Schommer, 1990; Schommer, 1993; Schommer & Dunnell, 1992; Schommer, Rhodes, & Crouse, 1992) have identified beliefs about an entity theory of intelligence, simple knowledge, certain knowledge, and quick learning as being strong predictors of students' cognitive performances and affective responses. Specifically, beliefs about intelligence predict students' goal choices and levels of sophistication of cognitive strategies (Diener & Dweck, 1978, 1980). Beliefs about knowledge and learning predict students' performances on mastery tests and self-estimates of comprehension of passages. Beliefs about learning also strongly predict types of conclusions students draw for an unfinished passage. A consistent finding is that students who believe in fixed intelligence, in simple knowledge, and in quick learning tend to avoid the obstacles, to resort to ineffective strategies, and to exhibit maladaptive behaviors in the face of difficulties and challenges (Diener & Dweck, 1978, 1980; Qian & Alvermann, 1995; Ryan, 1984; Schommer, 1990; Schommer, 1993; Schommer & Dunnell, 1992; Schommer et al., 1992). In a recent study, Schommer (1995) reported that people who believe in complex knowledge are more likely to reflect on and modify their point of view about an everyday controversial issue such as abortion.

Researchers who are interested in conceptual change learning found that beliefs about Simple-Certain Knowledge and Quick Learning predict students' conceptual understanding and applying a scientific notion in a different setting (Qian & Alvermann, 1995). The finding implied that students who have alternative

conceptions and naïve epistemological belief systems are less likely to meet the challenges and achieve conceptual change than students who have similar alternative conceptions but complex and mature belief systems. The present study further investigated the relationships between epistemological beliefs and conceptual change learning among innercity high school students.

Research on refutational text has demonstrated the positive effect on overcoming students' alternative conceptions (Guzzetti, Snyder, Glass, & Gamas, 1993; Maria, 1988; Maria & Johnson, 1989). Refutational text explicitly contrasts or challenges intuitive understandings of natural phenomena with scientifically accepted theories. Specifically, its effectiveness is shown when it is combined with strategies such as demonstration and the Discussion Web (Alvermann & Hynd, 1989; Hynd, Alvermann, & Qian, 1993; Qian & Alvermann, 1995), which directly challenge students' alternative conceptions.

In the study of conceptual change learning among secondary students, researchers compared effects of using different types of text on conceptual change learning, as well as documented students' preference to a particular type of text in a learning situation (Alvermann & Hynd, 1989; Guzzetti, 1990; Guzzetti & Hynd, 1995; Qian & Alvermann, 1995; Swafford, 1989). Students generally prefer refutational and expository text to nonrefutational narrative text in conceptual change learning (Guzzetti & Hynd, 1995). Students' preference may be related to the superiority of refutational expository to refutational narrative text in facilitating conceptual change (Alvermann & Hynd, 1989; Qian & Alvermann, 1995). The Alvermann and Hynd study showed that the use of story-like structure in overcoming alternative conceptions was not effective with secondary students. However, in the studies of conceptual change, conceptual change over time was not directly assessed due to the unequitable measures used as pre- and posttests. The present study

text on conceptual change learning.

Based on the previous research on types of text, motivational goals, and epistemological beliefs, three research questions were asked in the present study. First, was refutational text effective in facilitating conceptual change among innercity high school students who needed to accrete, tune, and restructure their prior knowledge? Second, were epistemological beliefs related to motivational goals? Third, to what extent could conceptual change learning be predicted and explained by epistemological beliefs and motivational goals among students who needed to accrete, tune, and restructure their prior knowledge?

Method

Participants

The sample included 190 11th- and 12th-grade students from science classes at an innercity public high school in New York City. There were 95 students who were absent on the days when either pretests or posttests were administered. The data obtained from these 95 students were eliminated from the analyses; therefore, the final sample size was 95. Of the 95 students, 35 were boys (37%) and 60 were girls (63%). The mean age of the students was 17 years and 5 months. There were 51 11th-grade and 44 12th-grade students. Of the 95 students, there were 37 African Americans (39%), 13 Asian Americans (13%), 31 Hispanic Americans (33%), 6 students from other ethnic groups (7%), and 8 students (8%) who did not indicate their ethnicity.

Materials

Refutational text. A refutational expository text titled "Newton's Theory of Motion" was used in the study (Alvermann & Hynd, 1989; Alvermann et al., 1990). The text was suitable for ninth-grade students to read according to Fry's (1977) readability formula. The 606-word expository passage was adapted from an article

written for Scientific American (McCloskey, 1983). According to Alvermann and Hynd (1989), the accuracy of the information presented in the passage was verified by a University of Georgia Research Professor of Physics. The passage directly confronted alternative conceptions about Newton's first law of motion. In particular, it contradicted the notion of impetus theory, which was an incorrect pre-Newtonian conception of projectile motion.

Epistemological Belief Questionnaire. For the purpose of this study, a 32-item Epistemological Belief Questionnaire (Qian & Alvermann, 1995) was used. The questionnaire was adapted from Schommer's (Schommer & Dunnell, 1992) revised epistemological belief questionnaire for high school students. In the Qian and Alvermann (1995) study, three factors were identified as underlying the 32-item Epistemological Belief Questionnaire. They were: (a) learning is quick (15 items with alpha (internal consistency) equal to .79); (b) knowledge is simple and certain (11 items with alpha equal to .68); and (c) ability to learn is innate (6 items with alpha equal to .62). Three dimensions are identified as Quick Learning, Simple-Certain knowledge, and Innate Ability. The overall alpha for the revised Epistemological Belief Questionnaire was equal to .77.

Goal Orientation Questionnaire. A Goal Orientation Questionnaire has been adapted from a four-item subscale Extrinsic Goal Orientation and a seven-item subscale Intrinsic Goal Orientation in the Motivated Strategies for Learning Questionnaire (MSLQ) developed by Pintrich, Smith, Garcia, and McKeachie (1991). The Goal Orientation Questionnaire consists of a total of 11 items. Pintrich et al. (1991) reported that the subscales Intrinsic Goal Orientation and Extrinsic Goal Orientation had reliability coefficients .74 and .62 respectively.

Prior Knowledge Pretest and Achievement Posttest. The Prior Knowledge Test was administered in an effort to screen and classify students' existing knowledge

about Newton's law of motion. The Prior Knowledge Test consisted of four subtests: (a) the True/False Test, (b) the Application Problem, (c) Conceptual Understanding, and (d) Application Reasoning.

The 10-item True/False subtest was used in previous studies (Alvermann & Hynd, 1989; Alvermann et al., 1990). It was constructed to evaluate commonly held alternative conceptions about projectile motion. The two-item Application Problem subtest required students to study diagrams of a moving object and then indicate the path a projectile shot from a cannon would take. In addition, the subtest required students to provide the reasoning behind their choice.

The 20-item Conceptual Understanding subtest was transformed from Alvermann and Hynd's (1989) 20-item True/False Test into a four-alternative multiple-choice format. The test was designed to assess students' understanding of Newton's theory related to the path of a projectile. Alvermann et al. (1990) reported that the 20-item True/False Test had a reliability coefficient in the low .70s. The four-item Application Reasoning subtest required students to study diagrams of a moving object and then indicate the path the moving object would take. The test also required students to select a statement that best explains the reasoning behind their choices.

The Achievement Posttest consisted of the same subtests as the Prior Knowledge Pretest, but the subtests were administered in a different order, that is, (a) Conceptual Understanding, (b) Application Reasoning, (c) the True/False Test, and (d) the Application Problem.

Procedures

The Epistemological Belief Questionnaire, Motivational Goal Questionnaire, and Prior Knowledge Test were administered together two weeks prior to the start of the experiment. Two weeks later, students were required to learn Newton's theory of

motion by reading a refutational text. Students were told that they were going to investigate the concept of motion. Then they were asked to read and study the text as though they were studying for a test, using any method they wished to study the text. Students were given up to 15 minutes to read and study the passage. Then, they were required to work for three minutes on a word scramble. Finally, students had 30 minutes to finish the Achievement Test.

Classification of the Accretion, Tuning, and Restructuring Groups

The data on the Application Problem pretest were examined to classify students into three groups: (a) accretion, (b) tuning, and (c) restructuring. The accretion group consisted of students whose answers to the application questions were incomplete but correct (that is, they displayed no alternative conceptions). The tuning group consisted of students whose answers to the application questions showed some alternative conceptions. Finally, the restructuring group consisted of students who had misconceived knowledge of the concept on the Application Problem.

Results

Effects of Refutational Text

Four separate repeated measures ANOVAs were conducted using Prior Knowledge Type (accretion, tuning, and restructuring) as the between-subjects factor and Conceptual Change (pre- and posttest scores) as the within-subjects factor. The first analysis of variance, in which the True/False pre- and posttest scores were used as outcome measures, showed a significant main effect on Conceptual Change $F(1, 92)=79.68, p<.001$, but there was no significant interaction effect between Prior Knowledge Type and Conceptual Change. The second analysis of variance, in which the pre- and posttest scores of Conceptual Understanding were used as outcome measures, yielded a significant main effect on Conceptual Change $F(1, 92)=94.44, p<.001$, but there was no significant interaction effect between the Prior Knowledge

Type and Conceptual Change, $F(2, 92)=1.77, p>.05$. The third analysis of variance, in which the Application Problem pre- and posttest scores were used as outcome measures, indicated a significant interaction effect between Prior Knowledge Type and Conceptual Change, $F(2, 92)=11.30, p<.001$ and a significant main effect on Prior Knowledge Type $F(1, 92)=17.22, p<.001$. The fourth analysis of variance, in which the pre- and posttest scores of Application Reasoning were used as outcome measures, indicated a significant main effect on Conceptual Change ($F(1, 92)=25.89, p<.001$, but the analysis showed no significant interaction effect between Prior Knowledge Type and Conceptual Change. Table 1 summarizes the descriptive statistics.

 Insert Table 1 about here

Relationship Between Beliefs and Motivational Goals

A multiple regression analysis was used to examine the relationship between students' epistemological beliefs and motivational goals. The three factors (Quick Learning, Simple-Certain Knowledge, and Innate Ability) derived from the 32-item revised Epistemological Belief Questionnaire were used as predictors, and the score from the 11-item Goal Orientation Questionnaire was used as an outcome measure.

The results indicated that there was a statistically significant relationship between students' epistemological beliefs and motivational goals, $R=.35 F(3, 91)=4.25, p=.007, MS_e=29.58$. The regression model explained about 12% of the variance. Therefore, a moderate relationship was found to exist between students' epistemological beliefs and motivational goals.

Predictability of Beliefs and Motivational Goals

A canonical correlation analysis was conducted to examine whether students

who had immature beliefs about learning, knowledge, and ability, and who endorsed performance goals, would fail to overcome their naive theories in conceptual change learning. One set of variables consisted of Quick Learning, Simple-Certain knowledge, Innate Ability, and Goal Orientation, and the other set of variables consisted of Conceptual Understanding, Application Reasoning, the True/False Test, and the Application Problem. Means, standard deviations, and correlation coefficients for all variables are reported in Table 2. Correlation coefficients demonstrated that multicollinearity was not a serious problem for the data analysis. Only the first dimension was considered meaningful in terms of the amount of variance explained, based on both the magnitude of the R^2 and statistical tests of them (see Tables 3 and 4).

Insert Tables 3 and 4 about here

The structure coefficients associated with the four predictor variables for this meaningful dimension were as follows: Quick Learning, -.25; Simple-Certain Knowledge, -.65; Innate Ability, -.58; and Goal Orientation, .35. The first canonical factor loaded heavily on Simple-Certain Knowledge and to a lesser extent on Innate Ability and Goal Orientation. According to Huberty and Weisenbaker (1992), the importance of each predictor could be assessed by conducting four separate canonical correlation analyses, each with one predictor removed. In this study, four separate canonical correlation R^2 's were obtained so that comparisons could be made. The results indicated that R^2 dropped from an initial value of .12 to .9 (25% decrease) when Innate Ability was removed and to .10 (16% decrease) when Simple-Certain Knowledge or Goal Orientation were removed. In contrast, R^2 dropped insubstantially from .12 to .11 (8% decrease) when Quick Learning was removed.

Evidently, in predicting conceptual change learning among innercity high school students, Innate Ability, Simple-Certain Knowledge, and Goal Orientation were more important predictors than was Quick Learning.

Insert Table 5 about here

Discussion

The results of the study suggest: (a) the positive effects of refutational text on innercity high school students' conceptual change learning, (b) a significant interaction effect between the Prior Knowledge Type and Conceptual Change on the Application Problem, and (c) a significant relationship between students' epistemological beliefs and their motivational goals. In addition, Innate Ability has been found to contribute most to conceptual change learning in the present study.

Effect of Refutational Text

The finding that refutational text is effective in facilitating conceptual change learning among innercity high school students is consistent with literature on refutational text (Alvermann & Hynd, 1989; Guzzetti, 1990; Qian & Alvermann, 1995; Swafford, 1989). The finding in the present study helps clarify the issue whether conceptual change learning is fostered due to the effectiveness of the refutational text or to the artifacts of inequitable measures (e. g., Qian & Alvermann, 1995). In addition, the finding has added to the literature that the effectiveness of refutational text is replicated by involving ethnically diverse innercity high school students. Finally, the effectiveness of refutational text appears to be robust across all measures, that is, on Conceptual Understanding, Application Reasoning, the True/False Test, and the Application Problem.

The significant interaction between the kind of prior knowledge students possessed and conceptual change learning on the Application Problem indicated that the tuning and restructuring groups gained significantly, whereas the accretion group regressed from the application problem pretest. This finding suggests that the effects of refutational science text on the Application Problem are strong among students in the restructuring and tuning groups, relative to students in the accretion group. This finding supports the previous research on the effectiveness of refutational text in facilitating conceptual change learning especially among students who have existing alternative conceptions (Alvermann & Hynd, 1989; Guzzetti et al., 1993).

Contribution of Beliefs and Goals

The results of the study suggest a moderate association between: (a) epistemological beliefs and goal orientations and (b) Conceptual Understanding, Application Reasoning, the True/False Test, and the Application Problem. The moderate association between the two variable sets indicates that students who have immature beliefs about knowledge are less likely to relinquish their naive theories in conceptual change learning. This finding is consistent with previous literature on epistemological beliefs. Students' naive epistemological beliefs are strongly associated with ineffective strategies, negative affects, passivity, and lack of cognitive flexibility (Dweck & Leggett, 1988; Schommer, 1990; Schommer & Dunnell, 1992; Schommer et al., 1992). Studies of epistemological beliefs have demonstrated that in the face of difficulty and challenging tasks, students' academic performance is affected by their beliefs about intelligence (Dweck & Leggett, 1988), about knowledge (Qian & Alvermann, 1995; Schommer, 1990; Schommer & Dunnell, 1992; Schommer et al., 1992), and about learning (Ryan, 1984; Schommer, 1990; Schommer & Dunnell, 1992; Schommer et al., 1992).

The assessment of the relative importance of the predictors helps clarify

questions about which variables contribute substantially to conceptual change learning. Results obtained from structure coefficients in canonical correlation analyses indicate that beliefs about Innate Ability, Simple-Certain knowledge and Performance Goals contribute more to conceptual change learning than does Quick Learning.

The relatively greater contribution made by beliefs about Innate Ability to conceptual change learning suggests that innercity high school students' beliefs about ability to learn appear to be strongly associated with conceptual change learning. This finding, however, is not consistent with the results of other studies of epistemological beliefs (Qian & Alvermann, 1995; Schommer, 1990; Schommer & Dunnell, 1992; Schommer et al., 1992). Schommer and her colleagues found that beliefs about innate ability did not predict students' comprehension in their previous studies (Schommer, 1990; Schommer & Dunnell, 1992). In their most recent study (Qian & Alvermann, 1995), beliefs about Innate Ability contribute least to conceptual change learning as indicated by results obtained from canonical correlational analyses. Most studies in the literature have not documented that beliefs about innate ability predict students' academic performance (Schommer, 1990; Schommer & Dunnell, 1992; Schommer et al., 1992), although some have provided evidence of the association of innate ability with goal orientations, levels of cognitive functioning, and choice of challenging tasks (e.g., Dweck & Bempechat, 1983).

The finding that beliefs about Simple-Certain Knowledge is a more important predictor is consistent with previous research that shows students who believe knowledge is certain tend to draw absolute conclusions for an unfinished passage (Schommer, 1990). The relative importance of Simple-Certain Knowledge in conceptual change learning also provides support for findings in a series of studies (Qian & Alvermann, 1995; Schommer et al., 1992; Ryan, 1984). In those studies, the researchers found that students' beliefs about simple knowledge contributed

substantially to their overall performance on an achievement test, their overestimation of what they understood, their tendency to resort to relatively superficial text processing strategies, and their failure to relinquish alternative conceptions about the projectile motion.

The contribution of Performance Goals to conceptual change learning was also important. The nature of the correlation between the Performance Goals and conceptual change learning is interesting that the variable is positively associated conceptual change learning. The positive correlation has demonstrated that students who strongly endorse performance goals are more likely to overcome naive theories about the projectile motion. This finding parallels with Nicholls' (1984) description about ego-involvement and task-involvement. He argues that learning will be facilitated even if students are ego-involved. The worse case is that students are neither ego- nor task-involved. In the present study, innercity high students appear to thrive in conceptual change learning with strong performance goals.

In contrast, among predominantly European-American students, a negative correlation between students' goal orientations and conceptual change learning was documented (Qian, 1993). The significantly negative correlations between performance goals and overall achievement, and between performance goals and application reasoning indicate that students who endorse performance goals are less likely to overcome naive theories on overall achievement and application reasoning than those who endorse learning goals. A sizable body of literature has documented a very strong association of goal orientations with engagement of high level cognitive strategies and probability of using the strategies in accomplishing complex learning tasks (Farrell & Dweck, 1985; Meece, Bumenfeld, & Hoyle, 1988; Nolen, 1988; Pintrich, 1985; Pintrich, 1989; Pintrich & De Groot, 1990; Pintrich & Garcia, 1991).

Association Between Beliefs and Goals

The moderate relationship between the epistemological beliefs (Quick Learning, Simple-Certain Knowledge, and Innate Ability) and Performance Goals adds support for the relationship theorized by Dweck and Leggett (1988). According to Dweck and Leggett (1988), goal orientations are directly linked with and explained by belief systems. Goal orientations (performance goals versus learning goals) are believed to mediate between individuals' beliefs about intelligence and learned helplessness. The moderate association between belief systems and goals appears to support Dweck and Leggett's proposed theory about the relationship between naive belief systems and performance goals.

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Table 1

Means and Standard Deviations for the Accretion, Tuning, and Restructuring Groups

	True/False					Conceptual Understanding			
	Pretest (10 items)		Posttest (10 items)			Pretest (20 items)		Posttest (20 items)	
	<u>N</u>	<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>
Accretion	13	5.62	1.50	8.40	1.39	10.08	2.56	15.54	2.76
Tuning	62	4.21	1.37	6.29	1.80	9.26	2.38	12.73	3.00
Restructuring	20	3.75	1.83	6.40	2.41	8.05	1.61	12.25	3.61

	Application Problem					Application Reasoning			
	Pretest (2 items)		Posttest (2 items)			Pretest (4 items)		Posttest (4 items)	
	<u>N</u>	<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>
Accretion	13	9.39	2.33	5.70	4.38	5.61	1.50	8.39	1.39
Tuning	62	3.45	1.04	5.40	4.12	4.21	1.37	6.63	1.80
Restructuring	20	1.50	.51	4.35	4.11	3.75	1.83	6.40	2.42

Table 2

Means, Standard Deviations, and Correlation Matrix for the Study's Measures

Variable	Maximum Score	Mean	Standard Deviation	QL	SK	IA	PG	CU	AR	TF
Quick Learning (QL)	75	29.66	5.31							
Simple-Certain Knowledge (SK)	55	28.07	5.47	.01						
Innate Ability (IA)	30	13.03	3.44	.12	.42					
Performance Goals (PG)	55	32.52	5.46	.06 (.124)	.33 (.038)	.24 (.276)				
Conceptual Understanding (CU)	20	12.76	3.31	.00	-.24	-.14	-.18			
Application Reasoning (AR)	4	2.26	1.17	-.04	-.23	-.13	-.09	.72		
True/False Test (TF)	10	6.88	1.99	.07	-.18	.02	-.24	.65	.51	
Application Problem (AP)	6	3.32	1.48	.01	-.10	-.15	-.18	.38	.33	.22

Note: Number of cases = 95. The numbers in the parentheses beneath the correlation coefficients with motivational goals are the standardized regression coefficients.

Table 3

Multivariate Tests of Significance for Research Question Three: Eigenvalues and Canonical Correlations

Root No.	Eigenvalue	Canonical Correlation	Squared Correlation
1	.13445	.34	.12
2	.08431	.28	.08
3	.02360	.15	.02
4	.00245	.05	.00

Note: N=95.

Table 4

Multivariate Tests of Significance for Research Question Three: Dimension Reduction Analysis

Root	Wilks' Lambda	F	df	p
1 TO 4	.79247	1.76	16,355	.036
2 TO 4	.89878	1.42	9,284	.179
3 TO 4	.97456	.77	4,236	.549
4 TO 4	.99756	.29	1,119	.590

Note: N=95.

Table 5

Structure Coefficients and R^2 's from Canonical Correlation Analyses for Students in the Tuning and Restructuring Groups

Variable	Structure Coefficients	R^2	Rank
Innate Ability	-.58	.09	4
Performance Goals	.35	.10	3
Simple/Certain Knowledge	-.65	.10	2
<u>Quick Learning</u>	-.25	.11	1
Conceptual Understanding	.26		
Application Reasoning	.51		
True/False Test	-.34		
Application Problem	-.20		

Note: The coefficients under the column R^2 indicate the variance explained by each reduced model. The underlined Quick Learning indicates that the variable was found not to differ from $R^2 = .12$ obtained from the full model, which included all the predictors in the canonical correlation analysis. $N=95$.